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## BENJAMIN FRANKLIN AS METEOROLOGIST.

By PROFESSOR CLEVELAND ABBE.

*(Read April 20, 1906.)*

I have been requested by the chief of the Weather Bureau to represent him at this bi-centennial celebration and to express the profound respect that we have for Benjamin Franklin as the first meteorologist of America. It is true that we have records made by observers of the weather before he began his scientific activity, but the progress of meteorology has been such that we have now learned to put the philosophical investigator, that is to say, the man of research, far above the mere observer and recorder. Considered as a mere chronicle of passing events the study of the weather dates from the earliest ages; but considered as a rational investigation into its ultimate physical causes, or as the logical application of well established principles to the elucidation of unexplained phenomena, or as a system of research checked at every step by observations and experiments, the modern physical meteorology or theoretical meteorology, or dynamic meteorology deals exclusively with force or energy, and dates from the days of Galileo, Sir Isaac Newton, Huyghens, Descartes, Boyle and Gay-Lussac, with whom Benjamin Franklin was a worthy co-laborer.

At the present moment we are apt to apply the term "scientist" to one who devotes himself almost exclusively to some special department of research; but in Franklin's day those who contributed to research were generally occupied most of the time with other work, and this was notably true of him.

It is often remarked that events happening in one's childhood, or even a few years before one's birth, may produce such a profound impression on the whole community as to affect the general trend of one's thought and life; therefore, since Franklin did, from early youth, turn his attention so strongly toward natural phenomena, it may be worth while mentioning the fact that he was born in

January, 1706, and that shortly before this, on the 26th November, 1703, there was a most awful and destructive storm on the coast of England, in which a great number of merchants' vessels and crews were lost, as also thirteen sail of British men-of-war with fifteen hundred and nineteen men. This is the storm celebrated by Defoe's description, and to this day it must arouse the attention of every reader. Franklin was a child when in December, 1708, there occurred the coldest month experienced in New England up to that time, but I believe that we have no thermometric records for that time, as accurate thermometers, those made by Fahrenheit, were first brought to this country in 1720 by Dr. John Lining, of Charleston, S. C.

The various published editions of Franklin's writings have brought to public attention such a great variety of remarkable works that we are apt to think of him as a statesman, a printer, a philanthropist, an electrician and a patriot; but a careful study of his life and an examination of the great mass of unpublished manuscripts have shown that if he had done nothing else but his work in meteorology that alone would have entitled him to the highest rank. On this subject he thought and wrote for sixty years, from his diary of 1726 to his long range forecasts of 1786.

In the course of a study of old Philadelphia records, my attention has often been called to the profound influence exerted throughout this country and Europe by this great man. This present date is in fact the anniversary of his death and burial, yet we celebrate his birth and life, for he cannot be said to be dead and gone while the spirit that animated him still lives; while his influence is still felt; while his example is ever before us; while his words are repeated daily; while his maxims are the mottos of our own lives; while his monuments are everywhere and still increasing around us. He marked out the rules of life that will be followed for all time by reasonable men.

Right here let me stop to controvert an error that I have heard repeated today notwithstanding the most beautiful and truthful oration of yesterday by the Hon. Hampton L. Carson. I am told in effect that Franklin was not a religious man. There could not be a more monstrous error than this; it could only have emanated from

those who never knew him personally, but in distant places and distant years had heard repeated some of his pointed satires against superstition, dogmatic theology, priestly craft, hypocrisy and the union of church and state. To all such perversions of pure religion he was a lifelong enemy. Bred for a preacher and theologian; educated for the pulpit of the Church of the Puritans; thrown by his removal to Philadelphia into the companionship of honest Quakers; transferred to England to battle for Freedom from corrupt aristocratic government with its Established Church and persecuting clergy,—he, of all men, had occasion from childhood to investigate the foundations of our faith; he had learned to distinguish between that natural religion that is revealed in the heart of every good man, and the dogmas, forms and ceremonies by which the established union of church and state was controlling a large portion of Europe, England and America. His common sense rebelled against this alliance of error with power; he would have none of it. He believed in the Fatherhood of God; in a religion that should be a blessing to men; in an honest statement of what we know, as distinguished from what we imagine or believe. He searched the foundations of his own faith as carefully as he examined into the phenomena of nature; he applied the same rational logic to them both, and sought by independent thought and clear views to emancipate his friends and countrymen from abject subserviency to dogmatic teachers, who were, as he believed, blinded by their own ignorance, fettered by conservatism and beguiled by love of power and ease.

Being familiar with every line of the Holy Scriptures, far more so than many of his adversaries, and knowing how they misused the words of the Bible, he turned it against them, and by such satires as his proposed new version of the Bible, in 1760, held up to the severest public contempt the false courtiers that surrounded the king, thus goading them on to further acts of injustice and selfishness. In every case in which he seems to be violating all habits of reverential religious thought, you will, if you understand the circumstances of the occasion, find that he was, as it were, confounding his enemies out of their own mouths. Read his "Shavers and Trimmers" in the *Pennsylvania Gazette* for 1743, or the "Parable against Parsons," or the "Parable on Brotherly Love," and learn that there are

shavers and trimmers at court, at the bar, in church, and in state.

Now turn to his "Articles of Belief and Acts of Religion" in the reprint by Smyth, vol. 2, pp. 91-100, and then recall that this elaborate declaration of the very highest form of natural religion, fit to be reproduced in every prayer book and Bible the world over, is the earliest autograph we have from Franklin, being written by him at Philadelphia, November 20, 1728, and was his daily pocket companion to the end of his life! He had been back from London two years and had gone through many trials, "but God was with Joseph." This composition marks an epoch in his early life corresponding precisely to what is frequently spoken of as "conversion"; but it was a conversion from men's devices to the higher and larger spiritual "republic of God." This "Articles" is a document that can be read only with the deepest reverence and affords us the true measure of the religious inner life of the noblest of men,—Benjamin Franklin. It fully explains how it happened that from 1753 to the end of his life Franklin was the most intimate companion and friend of "the good Bishop of Asaph."

If we systematically search for evidences of Franklin's interest in meteorology we shall find that in 1726, on his return voyage from London to Philadelphia, he kept a regular diary including items of wind and weather, noting, for instance, on August 30, 1726, "the full moon with a rainbow in the cloud to the west of us, the first lunar rainbow I have ever seen." Again, on September 14, "about 2 P. M. a solar eclipse covering ten-twelfth of the sun's diameter"; and on September 26th, "a sudden squall and rain, but the wind backed to northeast." Again, on September 28th, "run into gulf weed with barnacles and crabs" such as he seems never to have seen on the seashore, he even kept living specimens to see if more such crabs would hatch out, noting that they resembled the crabs he once saw in salt water at Boston and Portsmouth. On September 30th he sits up to observe the eclipse of the moon, which he says "occurred at 5 A. M. September 30th by the London Calendar, but at 11 P. M. September 29th to 2 A. M. September 30th by local ships' time," hence he calculates "that we are now four and a half hours, or 67 degrees, west of Greenwich." October 2d he noted that the water was changing color as though they were near soundings, it changed

back again to blue on the 7th; and on the 11th they anchored at Red Bank, six miles from Philadelphia.

Having become proprietor of the *Pennsylvania Gazette* in October, 1729, he published therein an article on earthquakes (compiled, of course, from many sources, to which he gives full credit), as he says, "because of the interest excited in the subject by our recent earthquakes," alluding to slight local earthquakes of 1725 and 1726, that were felt throughout the allied colonies and roused many queries and fears. His editorial work stimulated his habits of reading and writing. He made notes of everything that could be useful to his readers. . . .

In 1726, August 21st, occurred the destruction of Peruna, Italy. In 1740 occurred the great earthquake at Lima. In 1750, that at Concepcion in Chili. On November 1, 1755, a part of Lisbon was swallowed up by an earthquake, sixty thousand persons perished in a few minutes and the ocean flowed over the site of the disaster. In 1755, October 30th, Damascus was destroyed and twelve thousand lives were lost. In 1760, November 25th, Tripoli was destroyed. These were the great earthquakes to which attention was forcibly directed during his early manhood, and such events must be associated with his own intellectual activity.

From 1732 to 1757 there were 25 annual issues of his "Richard Saunders Almanack." Now while it is true that in these he published conjectures as to the weather during the respective years, yet we are not to think of Franklin as a planetary meteorologist; for the fact is that in every one of these issues he disclaims all knowledge of the weather or astrology and pokes fun at his own predictions as utterly absurd and useless. He gives them, as he says, for what they are worth as food for reflection, as matters that are an essential part of a farmer's almanac,—not based upon any knowledge of nature but simply fanciful conjectures. They served, of course, to make his almanac sell, but they were not put forth in any serious vein of thought, but were really to him a matter of humor and fun. For instance, in his preface to his almanac for 1738 he makes "Mystriss Saunders" apologize for the imperfections of the almanac owing to the sudden departure of the husband, "poor Dick"; she adds, "upon looking over the months I see he has put in

abundance of foul weather this year and therefore, I have scattered here and there where I could find room, some fair, pleasant, sunshiny, for the good women to dry their clothes in. If it does not come to pass according to my desire I have shown my good will, however, and I hope they will take it in good part." I believe that all the prefaces to *Poor Richard's Almanac* have been reproduced in Smyth's edition of the writings of Benjamin Franklin, and their humor is so telling that one may well wonder why the most credulous person in those days should have imagined that there could have been anything serious or reliable in such almanac forecasts. Nothing can be more ironical and comical than the following illustration from the preface for 1739: "Ignorant men wonder how the astrologists foretell the weather so exactly unless we deal with the old black devil, alas! it is as easy as is this. The star gazer peeps at the heavens through a long glass; he sees perhaps Taurus or the great Bull in a mighty chafe stamping on the floor of his house, swaying his tail about, stretching out his neck and opening wide his mouth. It is natural from these appearances to judge that this furious bull is puffing, blowing and roaring. Distance being considered, and time allowed for all this to come down [to the earth]—there you have wind and thunder."

But Franklin's life was devoted to the work of promoting useful knowledge and abolishing ignorance, superstition and credulity. His guiding principles were close observation and logical experimentation, and as these succeeded perfectly in his hands in all manner of business and in his dealings with mankind, he did not see why they should not hold good in dealing with nature. His proposal of May 14, 1743, to form a society of ingenious men from all parts of the colonies, to maintain a constant correspondence, and his offering of himself as secretary to that great undertaking, involved such an expenditure of time, thought and money, that we may well consider him as the father of coöperative systematic research in this country, even though a similar idea had animated the Royal Society of London for many years before. He had freed himself from the trammels of theological connections, he was not afraid to see the truth and state the truth; he recognized the limitations of man, that we can not possibly know for a certainty anything except by personal

observation and that what we accept on the testimony of reliable witnesses must be capable of being tested by actual experiment or observation and by logical reasoning at any moment. He proposed that his new society should consider a long list of subjects mentioned by him specifically. This list did not include the weather or the atmosphere except by implication in the last paragraph, which reads thus: "and all philosophical experiments that let light into the nature of things, tend to increase the power of Man over Matter and multiply the conveniences or pleasures of life." (Smyth, vol. 2, p. 230.)

As we delve into the great store of manuscripts relating to his life that have been preserved for us by his own habitual carefulness, we find new points of contact between him and modern ideas. His long record as a patriot, as an ambassador, as a master of pure English, as an electrician, as a man of the world, as a devoted brother, husband and father, has served to obscure some other equally prominent features of his character and his activity. His brilliant discovery of the identity between lightning and the ordinary electricity of the electric machine was not a so-called stroke of genius, but the inevitable result of his most persistent habit of thought and study, namely the determination that every idea that should occur to him of a philosophical nature should as soon as possible be tested by experiment. Accordingly we find the following memorandum in his daily note book, for November 7, 1749; after enumerating several analogies between lightning and the ordinary electric flash he adds: "The electric fluid is attracted by points; we do not know whether this property is in lightning; but since they agree in all the particulars wherein we can already compare them, is it not probable that they agree likewise in this? Let the experiment be made."

This was in November, 1749, at Philadelphia, at the season when lightning was rare, but he prepared to make the experiment as soon as practicable, doing it quietly in order to avoid attracting public attention, for a crowd was very apt to gather about him wherever he appeared. He at first planned to use a pointed rod on a high building,—afterwards he thought of attaching this rod to a kite. His silk kite had a pointed steel bar attached to the kite line, the latter was insulated by a silken cord and a key was tied at the junction, so



that all the details imitated his laboratory experiments. It is evident that he did not expect any very dangerous shock, or shall we rather conclude that knowing the poor conducting power of the wet kite string, he knew that it would be unable to bring down any really dangerous amount of electricity, and that he therefore would not be risking his life when he touched his finger to the key and received those first delightful sparks of natural electricity from the clouds.

From boyhood Franklin had been accustomed to drill himself in all the arts of a good debater. Whatever subject was up for discussion he kept it in mind during his daily work and jotted down on opposite sides of a sheet of paper the arguments *pro* and *con*; the considerations that should have weight or none; the reasons for thinking this way or that. After crossing off all unimportant matters he would reduce the whole argument to a few terse sentences arranged in logical order. Precisely the same course was followed when in later years he turned his attention to natural philosophy. He tells us that having become prosperous in business by strict logical attention to every consideration that made for success, he, in 1747, believed himself to be in a position to retire from active business. He therefore engaged Mr. Hall as his partner, to take most of the labor of the concern off his mind. He built himself a new house, bought the electrical apparatus of Dr. Spence, of Boston, and added other pieces and proposed to devote himself to a life of philosophical inquiry, of literature and elegant ease. In this he was disappointed, as he writes many years afterwards. "My neighbors, finding that I was a man of leisure, insisted upon my carrying on many public duties, and finally sent me to the Assembly; so that my philosophical inquiries were greatly interrupted." His scientific reputation has, in fact, rested largely upon the work that he did in Philadelphia and London between 1747 and 1757, much of which was published many years later. At the close of that period his correspondence, observations and notes on experimental work seem to have been boxed up previous to his starting for London on his first mission for the people as against the Proprietors. Eventually his collection was removed for safety to the country outside of Philadelphia; a part of it was lost during the revolutionary troubles, and

another portion since then ; but much has survived, and by searching over the fragments that remain we find that Franklin was always inquiring into the ultimate causes, or as we now say, the physical causes, of natural phenomena. We sometimes speak of him as an electrician, but before he studied electricity and in fact during his whole life he was seeking for explanations of atmospheric phenomena, so that the records will bear me out in asserting that he was among the first and best of the meteorologists, as distinguished from the climatologists, of his day. He tested the forces of nature and searched the motives of men. As his barometer and three thermometers were always at hand in his library, and as he refers frequently to the atmospheric pressure and temperature I shall not be surprised to find some regular record of these elements among the mass of his manuscripts that have yet to be examined, and I am hopefully hunting for his earliest records of the climate of Philadelphia. All are familiar with his inventions of improvements in the barometer, thermometer, and hygrometer ; all know his important position as the discoverer of the progressive movement of the north-east wind and rain advancing from Georgia to New England. We must not forget that as postmaster at Philadelphia, 1737-53, and Postmaster General for all the colonies (1753-1775), he was traveling north or south incessantly, and handling reports from his local postmasters that showed him the conditions of the roads and the weather throughout the whole extent of his postal routes. No man was more familiar than he with all the current features of the country as to weather and crops, with the people and their mutual relations to each other, with the business and resources of the country. His argument as to the movement of the storm of 1743 was not a suspicion or guess, but a perfectly sound conclusion based on special inquiries and reports ; it was precisely what we now call a careful research. I have collected many forgotten items that will go far to establish his reputation for solid work as a meteorologist, but perhaps the most interesting paragraph, and the only one I need here quote, relates to what are now called long-range forecasts of the weather and the seasons. Although he had published his own " Poor Richard's Almanac " for twenty years with its conjectures as to the weather, based on planetary configurations, yet in every al-

manac, without exception, he had ridiculed the whole subject, while at the same time knowing that popular superstition and ignorance would cause his almanac to sell. His own ideas as to such forecasts were far above those of his readers, and honest inquiry in this direction was always near his own heart. In the last years of his life he thought he saw one rational connection between cold winters in Europe and the foggy character of the preceding summers. This led him to write a very conservative memoir dated at Passy, near Paris, May, 1784. It was published in the *Memoirs of the Manchester Society* and I reproduce it from *Writings of Benjamin Franklin* (Sparks), Vol. VI, pp. 455-456, (Bigelow) Vol. III, p. 488, as follows:

METEOROLOGICAL IMAGINATIONS AND CONJECTURES.

PASSY, May, 1784.

There seems to be a region high in the air over all countries, where it is always winter, where frost exists continually, since in the midst of summer, on the surface of the earth, ice falls often from above, in the form of hail.

Hailstones, of the great weight we sometimes find them, did not probably acquire their magnitude before they began to descend. The air, being eight hundred times rarer than water, is unable to support it but in the shape of vapor, a state in which its particles are separated. As soon as they are condensed by the cold of the upper regions, so as to form a drop, that drop begins to fall. If it freezes into a grain of ice, that ice descends. In descending, both the drop of water and the grain of ice are augmented by particles of the vapor they pass through in falling, and which they condense by coldness, and attach to themselves.

It is possible, that, in summer, much of what is rain when it arrives at the surface of the earth, might have been snow when it began its descent; but, being thawed in passing through the warm air near the surface, it is changed from snow into rain.

How immensely cold must be the original particle of hail, which forms the centre of the future hailstone, since it is capable of communicating sufficient cold, if I may so speak, to freeze all the mass of vapor condensed round it, and form a lump of perhaps six or eight ounces in weight!

When, in summer time, the sun is high, and continues long every day above the horizon, his rays strike the earth more directly, and with longer continuance, than in the winter; hence the surface is more heated, and to a greater depth, by the effect of those rays.

When rain falls on the heated earth, and soaks down into it, it carries down with it a great part of the heat, which by that means descends still deeper.

The mass of earth, to the depth perhaps of thirty feet, being thus heated to a certain degree, continues to retain its heat for some time. Thus the first snows, that fall in the beginning of winter, seldom lie long on the surface,

but are soon melted, and soon absorbed. After which, the winds, that blow over the country on which the snows had fallen, are not rendered so cold as they would have been, by those snows, if they had remained; and thus the approach of the severity of winter is retarded; and the extreme degree of its cold is not always at the time we might expect it, viz., when the sun is at its greatest distance, and the day shortest, but some time after that period, according to the English proverb, which says, "As the day lengthens, the cold strengthens"; the causes of refrigeration continuing to operate, while the sun returns too slowly, and his force continues too weak, to counteract them.

During several of the summer months of the year 1783, when the effects of the sun's rays to heat the earth in these northern regions should have been the greatest, there existed a constant fog over all Europe, and great part of North America. This fog was of a permanent nature; it was dry, and the rays of the sun seemed to have little effect towards dissipating it, as they easily do a moist fog, arising from water. They were indeed rendered so faint in passing through it, that, when collected in the focus of a burning-glass, they would scarce kindle brown paper. Of course, their summer effect in heating the earth was exceedingly diminished.

Hence the surface was early frozen.

Hence the first snows remained on it unmelted, and received continual additions.

Hence perhaps the winter of 1783-4, was more severe than any that happened for many years.

The cause of this universal fog is not yet ascertained. Whether it was adventitious to this earth, and merely a smoke proceeding from the consumption by fire of some of those great burning balls or globes which we happen to meet with in our course round the sun, and which are sometimes seen to kindle and be destroyed in passing our atmosphere, and whose smoke might be attracted and retained by our earth; or whether it was the vast quantity of smoke, long continuing to issue during the summer from Hecla, in Iceland, and that other volcano which arose out of the sea near that island, which smoke might be spread by various winds over the northern part of the world, is yet uncertain.

It seems however worth the inquiry, whether other hard winters, recorded in history, were preceded by similar permanent and widely extended summer fogs. Because, if found to be so, men might from such fogs conjecture the probability of a succeeding hard winter, and of the damage to be expected by the breaking up of frozen rivers in the spring; and take such measures as are possible and practicable, to secure themselves and effects from the mischiefs that attend the last."<sup>1</sup>

Franklin's argument may be condensed as follows: The soil is warmed during summer, and its heat comes back to warm the air during winter. Its effect on the air is felt until snow accumulates

<sup>1</sup> See Sparks, "Life of Benjamin Franklin," Vol. 6, 455-457.

on the ground, so that the severest cold is delayed until long after December 21st. The fog of the summer of 1783 cut off the sun's heat, and left the earth cold; hence early snows were not melted; hence the cold began earlier and became more intense. If in future years a similar summer fog occur, it may be safe to predict that a similar cold winter will follow.

Two years after this we find the following two letters,<sup>2</sup> from his sister, Mrs. Jane Mecom. The first is dated Boston, December 17, 1786: "Your predictions concerning a hard winter are beginning to be verified in a formidable manner. The snow has been so deep that we might have been buried alive were it not for the care of some good neighbors"; and again, her letter dated March 9, 1787: "Your prediction has held invariable thus far, and as it began in October I don't see why it may not hold until May, for any appearance yet to the contrary." Must we not infer from this that Franklin had actually sent her a prediction for a cold winter beginning with October, 1786? The letter by him containing this prediction has not yet been found, but we may be sure that when found it will have in it nothing of planetary meteorology and nothing but strictly logical conclusions based on some well-established facts. I am hunting for this lost letter, but meanwhile I add to the laurel that crowns him another leaf, as the pioneer of the rational long-range forecasters, and of the physical meteorologists who will, undoubtedly, in the future develop this difficult subject.

<sup>2</sup>These were first published at page 151 of the "Letters to Benjamin Franklin from his family and friends, 1751-1790," "author, W. D."; published by C. B. Richardson, 348 Broadway, New York, 1859. These letters had passed from William Temple Franklin to Dr. Franklin Becke.